SECTION I

Construction Layout and Measurements

1 Introduction

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CHAPTER ONE: INTRODUCTION

This chapter is intended to refresh and improve the technician's ability to solve problems and to do various calculations required in construction layout and determining pay quantities.

A calculator capable of at least simple trigonometry functions (sin, cos, tan) will be needed. An understanding of trigonometry is not required, as fill in the blank forms will be provided.

GENERAL DEFINITIONS

Before there is any discussion of construction layout and measurements, there needs to be an understanding of the definitions of the generally used figures in this process.

POLYGON

A closed figure bounded by straight lines lying in the same plane is known as a polygon. The sum of the interior angles of a closed polygon is equal to:

$$(N-2) \times 180^\circ$$

where:

N = number of sides

Thus, the sum of the interior angles of a triangle is 180 º, a rectangle is 360 º, a five sided figure is 540 º, etc.

TRIANGLE

A polygon of three sides

RIGHT TRIANGLE

A triangle which has one right angle (90 º)

ISOSCELES TRIANGLE

A triangle which has two equal sides and two equal angles

EQUILATERAL TRIANGLE

A triangle which has three equal sides and three equal angles

OBLIQUE TRIANGLE

A triangle which has no right angle and no two sides are equal

CONGRUENT TRIANGLES

Two triangles are congruent if their corresponding sides and corresponding angles are equal.

SIMILAR TRIANGLES

Two triangles are similar if their corresponding angles are equal and their corresponding sides are proportional.

RECTANGLE

A rectangle is a four-sided polygon whose angles are right angles. A square is a rectangle whose four sides are equal.

TRAPEZOID

A four-sided polygon which has two parallel sides and two non-parallel sides

CIRCLE

A closed plane curve, all points of which are equidistant from a point called the center

RADIUS

The distance from the center of the circle to any point on the circle

DIAMETER

The distance across the circle through the center

CHORD

A straight line between two points on a circle

ARC

Any part of the circle

SEMI-CIRCLE

An arc equal to one half the circumference of a circle

AREA DEFINITIONS

Area is the surface within a set of lines. Area is measured in square units, square inches, square feet, square miles, etc.

RECTANGLE

The area of a triangle is equal to the product of the length and the width.

$$A = L \times W$$

where:

L = length of rectangle
W = width of rectangle

TRIANGLE

The area of a triangle is expressed in terms of its base and altitude. Any side of a triangle may be called the base. The altitude is the perpendicular distance from the base to the vertex opposing the base. (An angle may be defined as the space between two lines diverging from a common point. This point is called the vertex.) The area of any triangle is:

$$A = \frac{1}{2} B \times H$$

where:

B = base length
H = altitude length

RIGHT TRIANGLE

The area of a right triangle is equal to one half the product of the base and the altitude.

AREA OF A TRIANGLE WITH KNOWN SIDES

If the length of the three sides of a triangle are known, the area may be calculated from:

$$A = \sqrt{s\,(s-a)\,(s-b)\,s-c)}$$

where:

a = area
s = ½ perimeter length
a,b,c = lengths of each of the sides

AREA OF A TRAPEZOID

The area of a trapezoid is equal to the average width times the altitude. Expressed in another way, the area is the sum of the bases times the height.

AREA OF A CIRCLE

The area of a circle is π times the square of its radius

$$A = \pi r^2$$

where:

A = area
r = radius of a circle

RISE AND CHORD

The area of a circular segment is determined by multiplying the chord length and rise by a coefficient from a table for ratios of rise and chord (Figure 1-1). The formula is as follows:

Area = c x b x Coefficient

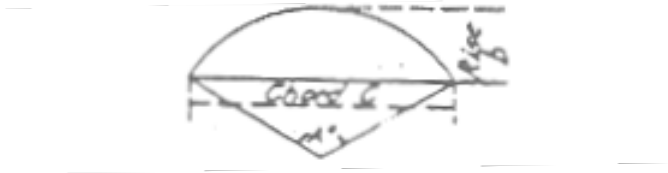
where:

c = chord length
b = rise

COMPOSITE AREAS

Irregular shaped areas may be divided into components and then the areas calculated. This method is very helpful where the technician is measuring sod, concrete driveways, etc.

AREA OF CIRCULAR SEGMENTS



Coefficient is given opposite the quotient of b divided by C
Area = C x b x Coefficient

Aº	Coefficient	b/C	Aº	Coefficient	b/C	Aº	Coefficient	b/C	Aº	Coefficient	b/C
1	.6667	.0022	46	.6722	.1017	91	.6895	.2097	136	.7239	.3373
2	.6667	.0044	47	.6724	.1040	92	.6901	.2122	137	.7249	.3404
3	.6667	.0066	48	.6727	.1063	93	.6906	.2148	138	.7260	.3436
4	.6667	.0087	49	.6729	.1086	94	.6912	.2174	139	.7270	.3469
5	.6667	.0109	50	.6732	.1109	95	.6918	.2200	140	.7281	.3501
6	.6667	.0131	51	.6734	.1131	96	.6924	.2226	141	.7292	.3534
7	.6668	.0153	52	.6737	.1154	97	.6930	.2252	142	.7303	.3567
8	.6668	.0175	53	.6740	.1177	98	.6936	.2279	143	.7314	.3600
9	.6669	.0197	54	.6743	.1200	99	.6942	.2305	144	.7325	.3633
10	.6670	.0215	55	.6746	.1224	100	.6948	.2332	145	.7336	.3666
11	.6670	.0240	56	.6749	.1247	101	.6954	.2358	146	.7348	.3700
12	.6671	.0262	57	.6752	.1270	102	.6961	.2385	147	.7360	.3734
13	.6672	.0284	58	.6755	.1293	103	.6967	.2412	148	.7372	.3768
14	.6672	.0306	59	.6758	.1316	104	.6974	.2439	149	.7384	.3802
15	.6673	.0328	60	.6761	.1340	105	.6980	.2466	150	.7396	.3837
16	.6674	.0350	61	.6764	.1363	106	.6987	.2493	151	.7408	.3871
17	.6674	.0372	62	.6768	.1387	107	.6994	.2520	152	.7421	.3906
18	.6675	.0394	63	.6771	.1410	108	.7001	.2548	153	.7434	.3942
19	.6676	.0416	64	.6775	.1434	109	.7008	.2575	154	.7447	.3977
20	.6677	.0437	65	.6779	.1457	110	.7015	.2603	155	.7460	.4013
21	.6678	.0459	66	.6782	.1481	111	.7022	.2631	156	.7473	.4049
22	.6679	.0481	67	.6786	.1505	112	.7030	.2659	157	.7486	.4085
23	.6680	.0504	68	.6790	.1529	113	.7037	.2687	158	.7500	.4122
24	.6681	.0526	69	.6794	.1553	114	.7045	.2715	159	.7514	.4159
25	.6682	.0548	70	.6797	.1577	115	.7052	.2743	160	.7528	.4196
26	.6684	.0570	71	.6801	.1601	116	.7060	.2772	161	.7542	.4233
27	.6685	.0592	72	.6805	.1625	117	.7068	.2800	162	.7557	.4270
28	.6687	.0614	73	.6809	.1649	118	.7076	.2829	163	.7571	.4308
29	.6688	.0636	74	.6814	.1673	119	.7084	.2858	164	.7586	.4346
30	.6690	.0658	75	.6818	.1697	120	.7092	.2887	165	.7601	.4385
31	.6691	.0681	76	.6822	.1722	121	.7100	.2916	166	.7616	.4424
32	.6693	.0703	77	.6826	.1746	122	.7109	.2945	167	.7632	.4463
33	.6694	.0725	75	.6831	.1771	123	.7117	.2975	168	.7648	.4502
34	.6696	.0747	79	.6835	.1795	124	.7126	.3004	169	.7664	.4542
35	.6698	.0770	80	.6840	.1820	125	.7134	.3034	170	.7680	.4582
36	.6700	.0792	81	.6844	.1845	126	.7143	.3064	171	.7696	.4622
37	.6702	.0814	82	.6849	.1869	127	.7152	.3094	172	.7712	.4663
38	.6704	.0837	83	.6854	.1894	128	.7161	.3124	173	.7729	.4704
39	.6706	.0859	84	.6859	.1919	129	.7170	.3155	174	.7746	.4745
40	.6708	.0882	85	.6864	.1944	130	.7180	.3185	175	.7763	.4787
41	.6710	.0904	86	.6869	.1970	131	.7189	.3216	176	.7781	.4828
42	.6712	.0927	87	.6874	.1995	132	.7199	.3247	177	.7799	.4871
43	.6714	.0949	88	.6879	.2020	133	.7209	.3278	178	.7817	.4914
44	.6717	.0972	89	.6884	.2046	134	.7219	.3309	179	.7835	.4957
45	.6719	.0995	90	.6890	.2071	135	.7229	.3341	180	.7854	.5000

Figure 1-1. Table for Ratios of Rise and Chord

ACCURACY OF CALCULATIONS

ROUNDING

When calculations are conducted, rounding is required to be in accordance with Section **109.01(a)** using the standard "5" up procedure. There are two rules for rounding numbers:

1. When the first digit discarded is less than 5, the last digit retained should not be changed.

   Examples: 2.4 becomes 2
   2.43 becomes 2.4
   2.434 becomes 2.43
   2.4341 becomes 2.434

2. When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.

   Examples: 2.6 becomes 3
   2.56 becomes 2.6
   2.416 becomes 2.42
   2.4157 becomes 2.416

DEGREE OF ACCURACY

The degree of accuracy is based on the dollar value of the bid item. All measurements are made to the nearest first decimal place (0.1). Calculations and final pay quantities are shown in the following table:

Unit Price Bid Amount	Field Measurements	Calculations & Sub Totals	Final Pay Quantity
$ 0 -9.99	0.1 unit	0.1 unit	1 unit
$ 10 – 99.9	0.1 unit	0.01 unit	.1 unit
$ 100 – 999	0.1 unit	0.01 unit	.01 unit
$ 1000 & above	0.1 unit	0.001 unit	.001 unit

A unit as shown in this table is the proposal unit.

EXCEPTIONS

Weigh tickets are considered original notes for many items and are required to be measured to the nearest 100 pounds.

Pavement striping and pipe (except concrete pipe) is measured and calculated to the nearest one foot. The Specifications for concrete pipe should be checked to determine the measurement units.

Seed and fertilizer is weighed to the nearest one pound.

Items whose proposal unit is listed as "each" or "lump sum" are measured or counted to that whole unit.

Linear grading is field measured to the nearest 0.001% of the unit, with calculations, sub totals, and final pay quantities as shown in the accuracy table.

Field measurements, calculations, sub totals and final pay quantity on herbicide contracts are made to the nearest one unit.